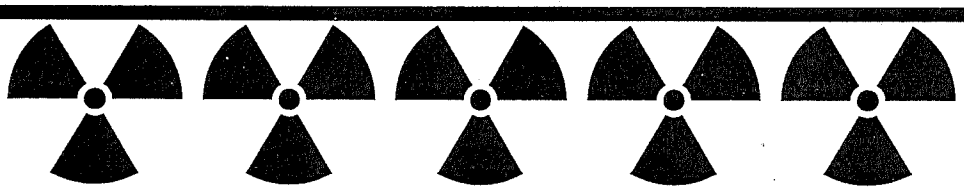
How Many Cancers?



Energy Probe's Written Submissions to the Advisory Committee on Environmental Standards on Proposed Limits for Tritium in Drinking Water

by Norman Rubin
Energy Probe
1994

Energy Probe
225 Brunswick Avenue, Toronto, Ontario M5S 2M6
Phone: (416) 964-9223 Fax (416) 964-8239

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Outline of *How Many Cancers?* -- Energy Probe's Written Submissions to the Advisory Committee on Environmental Standards (ACES) on Proposed Limits for Tritium in Drinking Water

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February 24, 1994

Dr. Mark Goldberg, Chair
Dr. Ralph Stanley, Tritium Working Group Chair,
Advisory Committee on Environmental Standards
40 St. Clair Ave. West, Suite 401
Toronto, Ontario M4V 1M2

Dear Drs. Goldberg and Stanley:

Thank you for the opportunity to make a submission regarding the proposed Interim Ontario Drinking Water Objective (ODWO) for tritium and the rationale behind that proposal. As you may know, Energy Probe and I have been concerned about emissions of tritium and other radionuclides into Ontario surface waters for several years, and were in contact earlier with the Environmental Assessment Advisory Committee, one of whose recommendations led to the present terms of reference for your Committee.

Directly following are Energy Probe's written submissions on this topic, along with two excerpts from our recently invited submission to the Atomic Energy Control Board's Staff Allocation Project regarding AECB's priorities and how we feel they should change. These deal with (1) the regulatory vacuum concerning "routine" radioactive emissions, and (2) the excesses of childhood leukemia and Down's Syndrome around Ontario Hydro's CANDU stations, which I hope you will agree (and as I will explain) are relevant to the decision you have to make.

In addition to these documents, we have very extensive files on these issues, including all of the documents mentioned in these submissions, or documenting the truth of the claims we have made here. Please feel free, and tell your staff to feel free, to contact me if any further information or documentation would be helpful to you in arriving at your recommendations and writing your report.

Specifically, I have recommended one relevant 300-page collection to your staff -- "Materials relating to radioactive emissions, health, environment, and regulation", which was (Energy Probe's) Exhibit #597 at the EA hearing into Ontario Hydro's Demand/Supply Plan, "the D/SP Hearing". This collection documents much of the long history of neglect, ignored recommendations, and missed opportunities which has made your 1994 investigation so welcome and so overdue. If your staff has difficulty getting a copy from the staff of the Environmental Assessment Advisory Committee, I have offered to make a copy.

Energy Probe Research Foundation
225 BRUNSWICK AVENUE, TORONTO, ONTARIO M5S 2M6 Phone (416) 964-9223 Fax (416) 964-8239

Our submission is organized as follows:

1. The only significant sources of elevated levels of tritium in Ontario's drinking water, now and for the foreseeable future, are emissions, overwhelmingly preventable, from nuclear reactors owned by Ontario Hydro or Atomic Energy of Canada Ltd.;
2. Environmental standards and emission controls are generally preferable to drinking-water standards, for artificial toxic pollutants;
3. There is currently a total absence of environmental standards or emission controls for tritium -- a "regulatory vacuum". As a result, tritium abatement efforts are much too low, and tritium emissions much too high;
4. The function and level of a drinking-water objective must logically be affected by the absence of emission controls, and should be set at the level equivalent to emission abatement using Best Available Technology Economically Achievable or "BATEA". Better yet, ACES should convince the Ontario government to remedy this regulatory vacuum;
5. The proposed Interim Ontario Drinking Water Objective (ODWO) for tritium is several hundred times higher than that level, and must therefore be rejected as much too lax;
6. Even if ACES rejects this logic, and treats tritium in drinking water as God-given, out of human control, and restricts its investigation to recommending an ODWO for tritium based only on the acceptable risk to human health, the proposed ODWO is still hundreds of times too high or too lax;
7. In addition, the Ministry of Environment and Energy's *Rationale Document* presents a very misleading and inadequate basis for deciding on an Interim ODWO; and
8. Energy Probe's recommendations.

The last part of our section 7, and our recommendation 3, deal with one aspect of "the effects of short-term exposure to sudden elevated levels in drinking water", which was also addressed in the EAAC recommendation.

Thank you again for the invitation to make a submission, and for your attention to this important matter. I look forward to meeting with you and your Committee on Monday.

Sincerely,

Norman Rubin
Director, Nuclear Research

attachments

Energy Probe's written submission to
the Advisory Committee on Environmental Standards
regarding the proposed
Interim Ontario Drinking Water Objective for Tritium

Norman Rubin, Director of Nuclear Research
February 24, 1994

1. The only significant sources of elevated levels of tritium in Ontario's drinking water, now and for the foreseeable future, are direct and indirect emissions -- overwhelmingly preventable emissions -- from nuclear reactors owned by Ontario Hydro or Atomic Energy of Canada Ltd..[1]

2. The best way to reduce the level of any and all toxic pollutants in drinking water (radioactive or not) is to keep them out of the environment -- as, for example, the International Joint Commission has just reaffirmed, and as is recognized at the heart of Ontario's MISA program (Municipal-Industrial Strategy for Abatement [of water pollution]).[2] This is so for two main reasons:

- Any protective measures taken after the toxic pollutant is emitted into the environment fail to address the root cause of the problem -- the toxic emissions themselves -- and generally

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1. See section 7, below, for a detailed comparison of this source with the other, relatively insignificant sources, especially natural production.

2. Unfortunately, existing MISA regulations governing nuclear reactors (*monitoring* regulations) expressly exempt their radioactive emissions from monitoring, characterization, and toxicity testing. MISA *emissions* regulations for the electricity generation sector have not yet been released, even in draft, but the recently released draft emissions regulations for the Metal Mining Sector (which govern CAMECO's uranium refinery at Port Hope) perpetuate this exemption -- over the express objections of the MISA Advisory Committee. For documentation of the exemptions for nuclear reactors, see "Materials relating to radioactive emissions, health, environment, and regulation", (Energy Probe's) Exhibit #597 at the EA hearing into Ontario Hydro's Demand/Supply Plan, especially pp. 165-224.

benefit only human health.[1]

- The focus on drinking water narrows the discussion of pollution levels to the costs and benefits to the health of a limited human population, and generally ignores the costs and benefits to other humans and other species, as well as the costs and benefits to humans through mechanisms other than health effects.[2]

For this reason, toxic pollutants should preferably be controlled "at the source" (*e.g.*, with environmental emission standards),[3] and not with Drinking Water standards or objectives.

3. Tritium is not effectively being kept out of the environment now. Tritium emissions are not subject to MISA or any equivalent requirements for Best Available Technology Economically Achievable or "BATEA".[4] The only regulatory "limits" on tritium emissions (the Atomic Energy Control Board's "Derived Emission

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1. For example, an exceedence of Ontario Drinking Water Objectives could be addressed with the installation of improved water-treatment technology in, or the closure of, one or more Water Treatment Plants. Neither action would benefit the aquatic ecosystem, or even the health of humans downstream of those specific Water Treatment Plants.

2. For example, we believe that Ontarians would place very significant value on (for example) decreasing the total loading of carcinogenic toxins in Lake Ontario, well above and beyond the scientifically provable health benefit that would accrue from drinking the tiny part of Lake Ontario water that is consumed by humans in Southern Ontario.

3. Other possible mechanisms for controlling emissions at the source include emissions taxes, tradable emissions permits below a legislated "cap", and legal rights for those affected by the emissions (*e.g.*, riparian, property, or environmental rights).

4. In 1984, Environment Canada attempted to apply comparable environmental standards -- based on "Best Practicable Technology" for abating emissions of persistent toxins -- to the design phase of new CANDU nuclear stations (as they did, successfully, to fossil-fuel plants) through the issuance of a draft Environmental Code of Practice. At the end of the ensuing eruption of nuclear-establishment objections, virtually nothing remained of the effort. see "Materials relating to radioactive emissions, health, environment, and regulation", (Energy Probe's) Exhibit #597 at the EA hearing into Ontario Hydro's Demand/Supply Plan, especially pp. 227-295.

Limits") are so lax that they do not actually limit anything.[1]

As a result, some tritium ends up in drinking water after it is *intentionally* emitted. For example, Ontario Hydro pumps out, on average, two 75-tonne tanks of radioactive liquid wastes (which would normally contain tritium) per day at each of their five nuclear stations.[2] As well, Ontario Hydro currently removes tritium from waste oil (at Bruce station) and vents it to the atmosphere, where it is known to convert into tritiated water in a short time (through both oxidation and ion exchange).[3]

Much of the rest escapes because of the practices and technology used to contain it are inadequate -- far below the level of Best Available Technology Economically Achievable. For example, tritiated heavy water has entered Lake Huron from the Bruce Nuclear plant because a loading area, where a truck spilled some of its cargo, drained directly into the lake. As well, all of Ontario Hydro's nuclear reactors use single-walled heat exchangers as the sole barrier between the reactors' moderator (the most tritium-contaminated heavy water in a CANDU reactor) and the neighbouring Great Lake, a source of drinking water. Any leak, perforation, or breakage in the extensive and complex geometry of any of those single-walled "moderator heat exchangers" inevitably brings large quantities of tritium into

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1. For more detail on this regulatory vacuum, see the attached document entitled "**The regulatory vacuum concerning 'routine' radioactive emissions** (Section 6 of Energy Probe's February 16, 1994 submission to AECB's Staff Allocation Project)". Ironically, Ontario Hydro's main control strategy to limit tritium emissions into the environment -- extracting tritium from the "heavy water" in CANDU reactors and storing it in pure or elemental form -- may actually end up increasing tritium emissions, since the conversion to elemental form results in a further regulatory "loophole", namely an enormous (~1000-fold) increase in the tritium emissions permitted by the AECB.

2. See "Materials relating to radioactive emissions, health, environment, and regulation", Exhibit #597 at the D/SP-EA hearing, especially p. 150.

3. See *Ontario Hydro's 1992 Environmental Performance*, p. 27, section 7.4, "Radioactive Materials and Wastes". Interestingly, the text seems to indicate that these emissions are regulated by the Ontario government (which has declined jurisdiction under MISA): "The tritium is released to the atmosphere since the amounts are within allowable Certificate of Approval limits."

direct contact with lake water and drinking water.[1]

A leak in one such moderator heat exchanger, at Unit 1 of the Pickering A station on August 2, 1992, caused the largest accidental tritium release in the history of the CANDU program (and probably in the history of the world), prompting the Ontario government to temporarily close at least one nearby water treatment plant. That record-breaking leak contained over 54,000 Curies or 2000 *Tera*Becquerels (= 2 *quadrillion* radioactive disintegrations per second) of tritium, which represent, if ingested, approximately 10,000 adult human LD_{50} doses of tritium and roughly 4,000 adult human statistically expected cancer doses. (For human infants, the corresponding figures would be 30,000 and roughly 12,000, respectively; calculations on request.) That enormous leak[2] also constituted only 3% of the AECB's *monthly* "Derived Release Limit" for tritium from the Pickering station. At Darlington, the same leak would have constituted only 0.3% of that station's even more lax monthly Release Limit.

4. ACES and the Ontario government should be mindful of the regulatory vacuum concerning tritium emissions into Ontario's surface waters and should attempt to remedy it. Failing that, ACES must compensate for that regulatory vacuum -- and the sloppy practices that are taking place because of that regulatory vacuum -- by attempting to set an interim drinking water standard for tritium that really is "as low as reasonably achievable" -- *i.e.*, one that reflects the levels that would be attained from the use of Best Available Technology Economically Achievable at the source of the tritium emissions.

5. The proposed Interim Ontario Drinking Water Objective (ODWO)

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1. We understand that the Gentilly-2 nuclear station in Quebec and the Point Lepreau nuclear station in New Brunswick both use moderator heat exchangers that make such emissions virtually impossible -- although the purpose of installing this superior technology was actually to protect the plant from the surface water, rather than the other way around. In either case, it seems hard to argue that this much better technology is not Economically Achievable.

2. The one leak, as discussed below in section 7, was twice as large as the annual production of tritium in the upper atmosphere globally.

for tritium of 7000 Bq/l[1] is almost 19 times higher than the highest level measured in 1991 in any water treatment plant in Ontario -- 370 Bq/l at Petawawa, according to Appendix E.2. of the *Rationale Document*.[2] Petawawa is immediately downstream of AECL's Chalk River Nuclear Laboratories, including the NRX and NRU reactors, and that level must obviously have been the result of an extraordinary release. The proposed ODWO is also, judging by Appendix E.1 of the *Rationale Document*, approximately 700 times higher than the "background" level in Ontario (that level itself the sum of natural tritium at terrestrial equilibrium levels, and nuclear weapons-testing tritium at declining levels). Clearly, this proposed ODWO is hundreds of times higher than levels that are "reasonably achievable" or that could be attained if Best Available Technology Economically Achievable were used to prevent and abate tritium emissions.[3]

6. Even within the strict, narrow, human-health terms of a Drinking Water Objective, in the (contrafactual) context of adequate emissions regulations, the proposed ODWO is far too high (too lax) to correspond to an acceptable human health risk, for the following reasons:

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1. Under this Interim Objective, each litre of Ontario drinking water could contain 7000 Becquerels of tritium -- the amount of tritium that would undergo 7000 radioactive disintegrations (and beta-ray emissions) per second. Since tritium is very radioactive (approximately 10,000 Curies or 370 billion Bq per gram), that amount of tritium is physically minuscule -- approximately 19 nanograms, or about one fiftieth of a millionth of a gram -- yet relatively easily detected because of its radioactivity.

2. *RATIONALE DOCUMENT FOR THE DEVELOPMENT OF AN INTERIM ONTARIO DRINKING WATER OBJECTIVE FOR TRITIUM*, prepared by Goff Jenkins, Standards Development Branch, Ministry of Environment and Energy, November 1993.

3. Energy Probe's candidate list of BATEA requirements for CANDU stations would include improved or newly installed emissions monitors, improved procedures, improved hardware (especially moderator heat exchangers, as discussed above), and drains and sumps that don't drain directly into the lake.
Unfortunately, Ontario Hydro declined on the basis of ignorance when asked by Energy Probe (in interrogatory 9.2.126 at the "D/SP" EA Hearing) to categorize its radioactive emissions into intentional vs. accidental emissions, and to estimate the proportion of the accidental emissions hat were caused by moderator heat exchangers. See "Materials relating to radioactive emissions, health, environment, and regulation", Exhibit #597 at the D/SP-EA hearing, p. 144. We have no indication that Ontario Hydro has since gathered that information, which might have been required under the monitoring phase of MISA, if these emissions hadn't been expressly exempted.

- The risk estimates on which the ODWO is based assume, contrafactually, that cancer is the only unfortunate health effect of consuming tritium. The first full paragraph of p. 7 is presumably supposed to justify the omission of genetic effects. Unfortunately, since the Atomic Energy Control Board has neglected to pursue further studies into the excesses of Down's Syndrome and childhood leukemia near the Pickering and Bruce nuclear stations, nobody has a firm, factual basis for assigning a cause for these excesses. In the face of that uncertainty, it would appear prudent to assume that tritium -- apparently the health-dominant emission from those stations -- is implicated. (Basing the tritium ODWO on that assumption might also have the salutary effect of motivating those important studies.)[1]

- The risk estimates on which the ODWO is based assume, contrafactually, that tritium is the only radionuclide (if not even the only carcinogen) in drinking water. The last two paragraphs in Section 7.5 (p. 13) add more confusion than justification to the choice of this erroneous assumption.

- The official sources of the risk coefficients for radiation carcinogenesis that underlie the proposed ODWO -- ICRP, UNSCEAR, BEIR, and WHO -- have, for whatever reasons, consistently underestimated the actual effectiveness of radiation at causing cancer. That is why the gradual accretion of factual data has consistently led to the raising of those coefficients.[2] There is no scientific or political reason to assume that this process has ended, or that believing today's estimates is adequately prudent. What *is* clear is that believing yesterday's (as the Canadian and Ontario governments did) was not adequately prudent.

- Even if the coefficients used are now finally correct, and the calculations of cancer risk are, too, we know of no reason to

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1. For more detail on this topic, see the attached document entitled "**Excesses of Childhood Leukemia and Birth Defects around CANDU Stations** (Section 4 of Energy Probe's February 16, 1994 submission to AECB's Staff Allocation Project)". See also the notes below under topic 7 for a discussion of the evidence that radiation in general and tritium in general leads to "non-specific life shortening" in experimental mice without any signs of cancer tumours or leukemia.

2. See, *e.g.*, page 2 of the *Rationale Document*: "The UNSCEAR and ICRP reports indicate that [their own] earlier reports underestimate the risk associated with radiation exposure." Needless to say, the authors of those earlier reports themselves indicated most emphatically that they had gotten the number right, or rather that they had most likely overestimated. Now even UNSCEAR and ICRP know better.

believe that Ontario's citizens, or their government, consider an additional five-per-million risk of fatal cancer an "acceptable" risk from one single contaminant in one year's drinking water.[1] A lifetime of that exposure would present a 300-per-million total additional risk of fatal cancer, and approximately a 750-per-million total additional risk of fatal or non-fatal cancer (as explained below). Even before multiplying times 9 million Ontarians, and times the total number of radionuclides and the total number of carcinogens they are exposed to, those figures all seem unacceptably high.[2] Obviously, anybody who was found to be (criminally) responsible for a tiny fraction of that number of deaths or illnesses in our society would either receive capital punishment or a life sentence. The legal penalty for civil responsibility for so much pain and suffering would also be enormous. We see no basis for a blanket pardon in the present instance, just because the victims are difficult or even impossible to identify.[3]

- The communities who would receive a health benefit from a low ODWO for tritium are precisely those who are now most at risk and most in need of and most deserving of that benefit. Specifically, they are now exposed to abnormally high tritium levels not only in their drinking water, but also in the air they breathe, the food they eat, the water they swim and bathe in, etc., as well as abnormally high exposures to radionuclides

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1. As discussed below, because of the toothless, non-binding nature of an ODWO, the level of risk it represents should not just be tolerable or marginally acceptable, but should be a significantly lower level of risk than just acceptable.

2. In addition to the obvious, quantitative reasons for this judgment, this particular risk has a number of qualitative aspects to it that are generally associated with lower levels of public risk acceptance: (1) the risk is involuntarily imposed, rather than voluntarily assumed; (2) the risk is a violation of what is considered in Ontario a basic right, to clean, pure, safe drinking water; (3) the risk includes a risk of cancer and a risk of genetic damage to our children, perhaps the two most dreaded human health risks.

3. I understand that some risk-based standards in the U.S. (perhaps for food additives) are based on the assumption that risk acceptability lies at or below a level of one (not five) cancer (fatal or non-fatal) per million from a lifetime (not a year's) exposure to the substance in question. That risk level -- approximately 750 times more stringent that the one embodied in the proposed ODWO -- would certainly seem more appropriate for our present-day society.

other than tritium.[1] As far as we can see, neither the proposed ODWO nor the WHO draft on which it is based takes these other exposures into account. (On the other hand, even an Interim ODWO as low as 100 or even 30 or 15 Bq/l would have no effect at all -- no health impact, and no direct socio-economic impact -- on Water Treatment Plants and communities that are outside the tritium-contaminated regions of Ontario Hydro's and AECL's nuclear reactors, since their tritium concentrations in drinking water are already below those levels.)

- Section 8 of the *Rationale Document* makes it absolutely clear that the Ontario Drinking Water Objectives (ODWOs), Canadian Drinking Water Guidelines (CDWGs), and WHO Guidelines are not standards, nor are they maximum concentrations, but only signals to pursue "certain courses of action".[2] In short, even if everything else is correct in the *Rationale Document*, there is no reasonable basis for confidence that actual concentrations of tritium would consistently remain below the level of an ODWO for tritium, or that the cancer risks from tritium in drinking water would consistently remain below those corresponding risk level. In this context, it seems absolutely foolhardy to delay the pursuit of "certain courses of action" until after health risks have reached the unacceptable levels calculated in the *Rationale Document*.

- In this context, we note the quiet disappearance in 1987 or 1988[3] of formal "target concentrations" for radionuclides in drinking water, previously set at 10% of the ODWO level (and equivalent Canadian Drinking Water Guideline level). We are told that that "target concentration" -- set at 4,000 Bq/litre for tritium -- "was judged to be meaningless and has been removed from the Objectives publications and the Canadian

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1. As mentioned above, there is epidemiological evidence that those populations are already experiencing detectable health detriment (from something), in the form of elevated childhood leukemia mortality and elevated incidence of Down's Syndrome. In the former case, parental (occupational) exposure to radiation before conception has been ruled out as a cause by an AECB-sponsored study.

2. Specifically, a WHO guideline, we are told at 8.1 (f), "is not specifically a limit but is a signal to pursue certain courses of action, such as investigation of the cause or implications of the elevated level". The description of both the CDWGs and the ODWOs, at sections 8.2 and 8.3, compares them to each other and the WHO Guidelines and says only that they "provide guidance as to the acceptability of public drinking water supplies".

3. The information in this paragraph is all taken from the statement of *Rationale Document* author Goff Jenkins, at pp. 19-20 of the transcript of the ACES Information Session of January 27, 1994.

Drinking Water Guidelines."[1] We do not understand, nor does Mr. Jenkins explain, why these targets were judged to be meaningless, or who did the judging. But given the weak, optional nature of the response to a "violation" of an ODWO, and the disappearance of any lower "target concentrations", it would seem reasonable and prudent to set the new ODWO at 10% of what might be judged a just-acceptable level of lifetime risk for exposure to this one single toxin for one single year's exposure to tap water -- identical in principle (though hardly in level!) to the now-defunct "target concentration".

7. In addition to the foregoing, the *Rationale Document* itself presents a very misleading and inadequate basis for deciding on an Interim ODWO. More specifically, it displays a consistent tendency to minimize concerns and obscure causal links, all the way from the source of the tritium to the ultimate health effects.[2] We urge ACES to ensure that these deficiencies are corrected (and certainly not repeated) in ACES's own report to the Minister. In addition, if there is some formal way for ACES to find that the *Rationale Document* is inadequate -- much as federal and Ontario Environment Assessment panels are called upon to judge the adequacy of the proponent's Environment Assessment documents, apart from judging the merits of the actual undertaking -- we would also urge ACES to do so, for the following reasons:[3]

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1. *ibid*, p. 20.

2. Despite these harsh words, we do not mean to impute ill intent to the *Rationale Document*'s author, Goff Jenkins, who has stated very clearly that he is a non-expert, brand-new to this field, and is relying on the work of other government and international agencies. (*E.g.*, on pp. 7, 8, and 9 of the January 27, 1994 transcript he makes several references to these facts.) Unfortunately, this field is so fraught with bias, half-truth, and inappropriate "perspective" that it is a veritable mine field for the uninitiated, and Mr. Jenkins seems to have detonated his share.

3. I have read the author's (Goff Jenkins's) comments at the ACES Information Session on January 27, 1994, in the hopes that they would correct the flaws of the *Rationale Document*. They do not. In fact, they include further false or misleading statements, apparently absent in the *Rationale Document*:

- Page 7 of the transcript suggests that there is regulatory control over tritium "emissions and discharges". There is effectively none, as outlined above and in the attached "regulatory vacuum" document.
- Page 9 suggests (crediting "our own Ministry of Health") "that one in every 7000 water molecules is actually a tritiated water molecule due to natural processes." If that were true, then

- The *Rationale Document* hardly deals with tritium as a toxin at all. In fact, it suddenly changes the subject from tritium on page 4 -- between Section 4.0 and Section 5.0 -- to "radiation" and "ionizing radiation", which are not really at issue here. Equating or mathematically "converting" the toxicity or carcinogenicity of tritium into that of a general form of ionizing radiation is like converting the world's currencies into Russian Rubles -- despite unsupported assertions to the contrary, in this case in Section 6.1 of the *Rationale Document*. In fact, a recent experimental attempt at AECL's Chalk River facility[1] to determine the actual "exchange rate"

...Continued...

each litre of water on Earth would contain about 3 *trillion* Bq of tritium, and we wouldn't worry about CANDU reactors -- or anything else, since even a cupful would contain several LD_{50}s!

- The way I read p. 9, medical exposures of radiation (which in any case have nothing to do with the matter at hand) are attributed, incorrectly, to "the fact that we live on this earth."
- The history of the latest ICRP/BEIR/WHO revisions, on pp. 11-12, contains at least two fundamental errors, which are no more relevant than that history itself.
- At the bottom of page 12 and the top of page 13, several references to cancer risks to people "exposed over a lifetime" should refer to *fatal* cancer risks over a lifetime *from exposure over only a single year*.
- At the top of page 13, it is claimed that ignoring all non-fatal cancers means that "the serious cancers are factored into this and taken into consideration"!
- In the first paragraph of page 14, it is suggested that a higher DWO "allows authorities the most latitude in dealing appropriately with contamination incidents". I don't see how, unless it means the most latitude to look away.
- On pp. 16-17, he indicates that AECB's "ALARA" limits (of 1% of the DRLs) are a voluntary Ontario Hydro target. They are not.
- On p. 17, he suggests that the Ontario government's philosophy would "not allow surface waters ... to deteriorate from their current condition." Has the increase in tritium concentrations stopped? Was this philosophy in place when Darlington began operations (and emissions)? I don't understand.

1. *RBE OF TRITIUM BETA RAYS FOR CAUSES OF DEATH OTHER THAN MYELOID LEUKEMIA IN MALE CBA/H MICE*, AECB Project No. 2.154.3, by D.K. Myers, J.S. Jackson, and D.W. Dunford, Chalk River Laboratories, AECL Research, published May 1991. (AECB publication # INFO-0384)

or "conversion factor"[1] that relates the health effects of tritium to those of a "standard" form of radiation (hard X-rays) found that the answer varied widely, depending on the rate and amount of tritium administered, and depending also on the specific "biological end-point" -- *i.e.*, the disease, the type of cancer, etc.[2] *Tritium, in short, is a priority pollutant, a persistent carcinogenic toxin in its own right, and it should be treated as such, not as a subset of some huge class of Bad Things.* I understand that his concept has recently been endorsed by the International Joint Commission. Specifically, the latest IJC report, which I have not yet seen, apparently indicates that IJC will be including all radionuclides with half-lives over 6 months, presumably including tritium, in their future lists of Persistent Toxins, whose emissions into the Great Lakes are to be "virtually eliminated". I am told that the report recommends that the governments on the Great Lakes do the same.

Accordingly, the following sections of the document should be retitled and rewritten, or ignored completely:

Section 5.0 -- "EXPOSURE TO IONIZING RADIATION" -- should be rewritten to deal with "EXPOSURE TO *TRITIUM*", which occurs through many more pathways and mechanisms than those discussed in the document -- including by way of consumption of tritium in purchased foods and home-grown foods (the latter presumably irrigated with "drinking" water). Those exposures -- some of them directly caused by tritium levels in tap water -- include exposures to compounds of tritium significantly more toxic than tritiated water ("HTO"), the only compound considered in this

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1. The technical term for this conversion factor -- basically the ratio between the observed health harm from a specific form of radiation and the energy it delivers -- is Relative Biological Effectiveness, or RBE. The RBE of "hard" or high-energy X-rays is set at 1.0, and other forms of radiation (like tritium's low-energy beta particle) are compared to it.

2. The radiation community's response is to choose a single number out of this "cloud" of experimental data, call it the "quality factor" or "Q" of that form of radiation, then to use it to convert Grays of absorbed dose into Sieverts of "effective dose" *as if it were the true Relative Biological Effectiveness of that form of radiation for any important health effects.* (In my experience, members of this community often forget how arbitrary and meaningless these "quality factors" -- and therefore the calculations of effective dose -- actually are.)
This same report also reported "a surprising decrease of time to death of animals without tumours ... in the irradiated groups of mice" [abstract, p. i.] and suggested [in the discussion of this issue at pp. 6-9] that further research might be warranted into "non-specific life shortening due to radiation exposure".

entire document. Probably the most important of these constitute a class of compounds called "Organically Bound Tritium" -- *i.e.*, organic compounds that incorporate radioactive tritium in place of normal hydrogen. These -- which would be especially formed by vegetable matter exposed to tritiated water -- are apparently significantly more toxic than tritiated water because our bodies (and those of animals in general) form the bulk of their own organic compounds out of organic compounds in our foods, rather than constructing them out of (say) water. While the tritium in tritiated water is itself clearly toxic and carcinogenic, the tritium in these organic compounds is much more so, because it is much more likely to incorporate itself into the molecular structure of our DNA, our proteins, fats, and carbohydrates than the tritium in tritiated water.[1]

Section 5.1 -- "Natural Sources of Radiation" -- should be rewritten to deal with "Natural Sources of *Tritium*". That section would clearly show that all the world's natural sources of tritium pale into insignificance beside Ontario Hydro's and AECL's CANDU reactors. For example, Section 4.0 indicates (following UNSCEAR) that 10^{15} Bq of tritium are produced annually by natural processes. That sounds like a big number, but it is *half* as much tritium as *leaked* out of Pickering Unit 1 on August 2, 1992. It is also *one one-thousandth* of the amount (10^{18} Bq) of tritium that is produced annually by Ontario Hydro's CANDU reactors. In the *Rationale Document*, those reactors -- the source of the toxin and the source of this entire discussion -- are mentioned only at the end of Section 4.0, as the last (and apparently the least!) of several

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1. It would therefore appear likely that the "garden pathway" from tritium in tap water to tritium in the human body is more efficient at causing health harm than the drinking pathway. Put another way, more tritium will get from the tap to my DNA if I water my raspberries, lettuce, tomatoes, etc., with it, then eat them, than if I drink it. At the very least, this pathway of harm is *additional* to the strictly drinking-water pathway that led to the proposed ODWO, which is therefore too high or lax in this regard.
For more information: Ontario Hydro's February 5, 1987 "Response to AECB Questions on the Darlington NGS Derived Emission LImit Report (SSD-86-1), Action Item OL-861323" explains that their calculation "does not consider the direct assimilation of organically bound tritium in foodstuffs into the bound compartment of human tissues," and argues against doing so. That Ontario Hydro document also refers to (and dismisses as "speculative") an article by C.C. Travis entitled "Tritium Hazard via the Ingestion Pathway", in *Fusion Technology*, September 1985. (I have not reviewed that article.)

sources of tritium.[1]

Section 5.2 -- "Other Sources of Radiation" -- should be rewritten to deal with "Other Sources of *Tritium*". Apart from a small (and apparently diminishing) number of tritium-illuminated exit signs in Ontario that might break or burn, there is not much to report.

Section 6.0 -- "HEALTH EFFECTS OF IONIZING RADIATION" -- should be rewritten to deal with "HEALTH EFFECTS OF *TRITIUM*", which (according to one study on mice at Chalk River, referenced above) includes "a surprising decrease of time to death", and which (according to epidemiological studies of children near Pickering and Bruce, discussed above and in an attached paper) may well include childhood leukemia and Down's Syndrome.

Section 6.1 -- "Assessing the Effective Dose of Radiation" should be rewritten to deal with "Assessing the Effective Dose of *Tritium*", which (as outlined above in the discussion of the Chalk River study on tritium's elusive Relative Biological Effectiveness) is still a very thorny and unresolved issue, even after fairly extensive research.[2] Further, the effective dose of tritium a person receives is a function of the chemical form of the tritium. (See above for a discussion of "Organically Bound Tritium", an important class of tritium compounds which is apparently never mentioned in the *Rationale Document*.)

It would be instructive to imagine (or to inspect) a Rationale Document for a proposed Drinking Water Objective for, say, *e. coli*, that lumped its effects together with all the world's

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1. That section first discusses naturally-formed tritium, then tritium produced in nuclear explosions, which is called "the source of most of the tritium in the *global* environment." Of course, it is certainly not the source of most of the tritium in the environment near Pickering, Bruce, or Chalk River. The following sentence then concludes that section: "Tritium *may* also be released into the environment in emissions from nuclear energy production facilities, in particular from CANDU type water-cooled reactors. [all emphasis added]"
With all due respect, this section would certainly seem to have been designed to mislead, like the first sentence in Section 3.0, third paragraph (p. 3).

2. These daunting difficulties are dismissed in the *Rationale Document* by facile reference to the "system of radiation and tissue weighting factors" developed by "the international scientific community". Of course, what cannot be resolved scientifically by Chalk River's best and brightest, building upon the international body of scientific knowledge, cannot logically be resolved by sending some of these same scientists to international meetings to arrive at arbitrary answers.

pathogenic microbes. Or one for dioxin, arsenic, or carbon tetrachloride that constantly lumped that toxic substance together with all the world's toxic substances.[1] In each case, as here, the effect of such a "lumping" would be to minimize or trivialize -- and hence to justify -- the exposure of people to many times the normal amounts of a single toxin. That trivialization would appear to be the purpose of the multiple references in this document to background radiation, in the aforementioned sections, and also at p. 9, last paragraph and p. 10, second paragraph.

- The discussion of cancer risks is extremely misleading for at least two reasons: (1) Because the phrase "per year" is consistently omitted from all mentions of the cancer risk (*e.g.*, no fewer than four times in the second paragraph on page 10), the document suggests that the cancer risk is approximately 60 times lower than it really is. (2) Because all references but one are to "cancers" and "cancer risk", when what is really being estimated is the risk of *fatal* cancers (which constitute roughly one-third to one-half of all radiation-induced cancers, according to most authorities), the document suggests that the actual cancer risk is another two or three times lower than it really is. Taken together, the actual estimated lifetime cancer risk, still using ICRP's risk estimates, is not 5×10^{-6} (or five cancers per million persons exposed), but roughly 150 times higher, *i.e.*, 750×10^{-6}, or *seven hundred and fifty cancers per million persons exposed.* That would constitute about 6,000 excess cancer cases among nine million Ontarians exposed at that rate.

- We can make no sense of the paraphrase of WHO's Draft Guidelines at the bottom of page 9 of the *Rationale Document*, especially the reference to "a lifetime exposure". The doses calculated from the ODWO, and the resulting risks of (fatal) cancers, are all based on calculating the additional risk of fatal cancer from an *annual*, not a lifetime, exposure to tritium at the level of the proposed ODWO. A higher annual exposure -- for any group in the population, for any reason, including those listed -- would naturally lead to a higher risk of fatal cancer than the one claimed on page 10. If that resulting risk of fatal cancer for that group isn't acceptable, then neither (obviously) is the proposed ODWO.

- The *Rationale Document* refers to difficulties of distinguishing one thing from another, as if that difficulty provides a rationale for the additional, artificial tritium exposure (and the additional, artificial health risk) that would result from the proposed ODWO. It does not. For example:

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1. I am eagerly awaiting arrival, in the mail, of ACES's report on NDMA (found in drinking water in Elmira around 1990). In the interim, I must simply express my confidence and hope that it does not suffer from this shortcoming.

P. 3: "Tritium is a naturally occurring radionuclide and *may* also be produced as a by-product in water-cooled nuclear reactors.[emphasis added]" Even if naturally occurring tritium were known to be responsible for all the health ills of our species, and the proposed ODWO sanctioned only a tiny increase in it, we would still have to judge the appropriateness of that increase -- the risk we create and can control. In fact, naturally occurring tritium, even globally, is tiny compared to Ontario Hydro's production, and is even small compared to Ontario Hydro's actual *releases*.[1]

p. 10: "At this level of exposure, any cancers that may result from radionuclides in drinking water are not detectable or distinguishable from the normal cancer incidence. Cancers due to background radiation cannot be distinguished from other cancers and, since exposure to natural background radiation cannot be avoided[2], they are simply part of the natural cancer incidence." Even assuming this is all true, we find in it no rationale for allowing the "natural background" level of tritium in Ontario's drinking water to increase by a factor of roughly 700 before the proposed ODWO would even trigger an investigation.

- The discussion in Appendix B, of the effects of short-term exposure to sudden elevated tritium levels in drinking water, is hopelessly inadequate. The only issue addressed there is the possibility that tritium levels could become so high as to cause "somatic" radiation illness -- a level more than 10,000 times higher than the proposed ODWO. But there are serious concerns at very much lower levels that need serious discussion. For example, as early as 1980, the Parliamentary Select Committee on Ontario Hydro Affairs heard expert testimony from Dr. Edwin Radford of University of Pittsburgh suggesting that one very significant pathway for human harm from elevated tritium levels was as follows:

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1. In the five years 1986-1990, according to Ontario Hydro's submissions to the "D/SP" EA Hearing, the Pickering and Bruce stations emitted a total of over 31,000 TeraBecquerels -- or 31 E+15 Becquerels (850,000 Curies) -- of tritium, in the form of tritium oxide, into the environment, both airborne and waterborne. If the *Rationale Document* is correct about the rate of natural production, Ontario Hydro has been *emitting* tritium at six times the rate of global natural production. Those five-year emissions, if all consumed by humans once and only once, as water, also correspond to approximately 150,000 human adult LD_{50} doses of tritiated water, and a slightly smaller number of expected cancer and genetic effects doses (calculations on request).

2. *Sic*: Does this apply to radon in homes? radon from "natural" uranium mine tailings? cosmic rays from airplane flights?

A female infant is born with all the eggs or ova she will ever produce as a mature woman. Those ova are formed during a relatively short period during her time *in utero*. If the "building materials" available during that short time are defective -- specifically, if the available hydrogen is tritiated -- an inordinately high percentage of her ova will incorporate that defective building material. Since tritium has a radioactive half-life of about 12 years, the majority of that would have already undergone radioactive decay by the time she would enter her own reproductive years. That radioactive decay would disproportionately disrupt the genetic material in her ova, and her offspring, in two different ways: by irradiating the surrounding genetic material with a very well-placed beta particle, and by converting a "meaningful" tritium or hydrogen atom (*e.g.*, in a crucial gene in the DNA code) into a "nonsensical" helium atom, thereby causing genetic damage.[1]

This phenomenon -- which Dr. Radford testified should form the basis for general tritium exposure limits, including the setting of AECB's Derived Release Limits -- has, to my knowledge, never been pursued or investigated in Ontario or in Canada. (If this phenomenon is real, as Dr. Radford testified, the health impacts from relatively modest concentrations of tritium in drinking water could be both very large and still to come, since relatively few women born in a tritium-contaminated environment would already have conceived children of their own.) The current mandate to ACES to report on this issue may be the opportunity we've been waiting for to investigate this important phenomenon.[2]

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1. When a single tritium atom decays radioactively, it emits a negatively charged beta particle (an energetic electron) and thereby gains one positive charge, transforming itself from H^3 or tritium to He^3, a non-radioactive, rare isotope of Helium. I do not recall Dr. Radford mentioning it, nor am I an expert in this field, but it seems logical to me that the sperm precursor cells of a male infant *in utero*, if they incorporated tritium while being formed, could also have a disproportionate impact on the genetic health of that male's own subsequent offspring.

2. After hearing from Dr. Radford and others, the Select Committee made two important (and still unimplemented) recommendations, for the establishment of a new Council, "independent of Ontario Hydro and the government," which should "give high priority to ... an independent review of the adequacy of current [and] proposed release limits for Carbon-14 and tritium, taking into account both local and global concerns." See "Materials relating to radioactive emissions, health, environment, and regulation", Exhibit #597 at the D/SP-EA hearing, pp. 61-65, especially p. 65.

8. Energy Probe's recommendations:

Recommendation 1: ACES should urge the Ontario Minister of Environment and Energy to begin treating tritium as a Priority Pollutant, which it obviously is, either by adding it to the *Emissions Monitoring Priority Pollutants List* and monitoring and controlling it under MISA regulations, or by adding it to the *Candidate Substances List for Bans or Phase-Outs*.[1]

Recommendation 2: Whether or not that recommendation is made or accepted, ACES should urge the Minister to set the ODWO for tritium at a level in the range of 10 to 30 Bq/l, if not lower.[2]

Recommendation 3: ACES should, if possible, use its present mandate to conduct an investigation of the (aforementioned) phenomenon of a short-term tritium "pulse" in drinking water consumed by a pregnant mother being incorporated into the human ova of her female child. Failing that, ACES should recommend that such an investigation be performed by the Ontario government, with participation from or consultation with the concerned public, including Energy Probe.

Recommendation 4: In its report to the Minister, ACES should endeavour to correct the many false or misleading statements in the *Rationale Document*, and should attempt to ensure that that report is circulated or made available to everybody who received the *Rationale Document*, whether or not they otherwise participated in this process. If possible and appropriate, ACES should make it clear that it considers the *Rationale Document* an inadequate basis for choosing an ODWO for tritium.

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1. In our view, as explained above, either of these outcomes would be more appropriate and more beneficial to the environment and human health than any attempt to control human tritium ingestion solely through an ODWO.

2. Correcting most or all of the inappropriate calculations in the *Rationale Document* (as outlined above) could easily lead to an ODWO level, based on a prudent approach to acceptable risk, that is lower than today's (post-weapons-testing) ambient tritium levels in Ontario, even in regions far from nuclear reactors. Although we have refrained from expressly recommending such a course, even these ambient tritium levels -- roughly 10 Bq/l -- may well pose a human health risk that Ontarians would consider acceptable. It is clear is that lowering those ambient tritium levels throughout the province would be somewhere between amazingly difficult and theoretically impossible (short of importing glacier-melt water), and would in any case have prohibitive socioeconomic impacts. But it is arguable that a decision to compromise the ODWO on those grounds should be made explicitly on the grounds of socioeconomic impacts, rather than implicitly, as if today's ambient levels had been proved acceptable, which we believe they have not.

APPENDIX I

The regulatory vacuum concerning "routine" radioactive emissions
(Section 6 of Energy Probe's February 16, 1994 submission to AECB's Staff Allocation Project)

AECB staff (and Board), in setting Derived Release Limits (or Derived Emission Limits -- DRLs or DELs) for nuclear reactors and other licensed facilities, have consistently ignored environmental impacts, used dose-response factors that are later found to be over-optimistic, ignored longer-term and longer-range effects, and generally failed to meaningfully restrict radioactive emissions. A few examples:

- The annual Derived Release Limits for tritium released from the Point Lepreau and Darlington nuclear stations are significantly higher than the total tritium contained in those stations. It would be physically impossible for them to hit or exceed those limits (or in Point Lepreau's case, to come within several orders of magnitude) without importing tritium from elsewhere. Whatever those "Derived Release Limits" are, they are obviously not really limits.

- The largest accidental tritium release in the history of the CANDU program (and probably in the history of the world), from one of the Pickering Unit 1 moderator heat exchangers on August 2, 1992, was large enough to prompt the Ontario government to close several nearby water treatment plants. That record-breaking leak constituted only 3% of the *monthly* Derived Release Limit for tritium from that station! (At Darlington, the same leak would have constituted only 0.3% of the monthly Derived Release Limit; at Point Lepreau, the fraction would be closer to 0.03%.)

- Release limits for pure or gaseous tritium are approximately 1000 times higher (more lax) than those for tritium oxide or tritiated water. That difference reflects the relative toxicity of the two forms, but ignores the fact that pure or gaseous tritium is completely oxidized -- *i.e.*, converted into the more toxic form -- in a matter of hours or a day or two. This "loophole" is important because Ontario Hydro is increasingly converting its tritium inventory into pure or gaseous form at the Darlington Tritium Removal Facility, and because Ontario Hydro intentionally (and needlessly) releases gaseous tritium into the environment at Bruce as part of a waste-oil purification process.

- For radioactive releases from all CANDU stations, the so-called "Action Levels", "targets", or "ALARA levels" (short for "As Low As Reasonably Achievable, social and economic factors taken into account") are set at 1% of the DRLs. In the case of Point Lepreau, even 1% of the annual DRL for tritium is significantly higher than all the tritium contained in the station. Whatever that "ALARA" level is, it is obviously not really as low as reasonably achievable.

- Although I believe that AECB Staff still have not formally

proposed a policy on ALARA to AECB Board, nearly four years after being asked to do so at the April 1990 Board meeting, it would appear from a preliminary proposal that the formula for ALARA levels, currently set at 1% of the DRLs, is more likely to increase than to decrease, as the continuing change in the coefficients of radiation-induced cancer causes DRLs to drop.

- Much of the radioactivity actually released from CANDU nuclear stations is intentionally released, *e.g.*, by twice-daily unfiltered pump-outs at each of Ontario Hydro's five CANDU stations. Most of the rest is released through relatively inexpensive barriers to release -- probably most notably, single-walled moderator heat-exchangers, the sole barrier between the heavily tritiated Moderator water and the adjacent lake, river, or ocean. Pumping unfiltered radioactive liquid wastes into a lake can hardly be called keeping emissions "as low as reasonably achievable".

- Wherever there is any regulatory overlap between AECB's emissions regulation and environmental regulation, *e.g.*, for uranium emissions to Lake Ontario from the uranium refinery in Port Hope, the environmental regulation is the stricter, and AECB's "limits" become academic.

- AECB staff have worked to preserve this regulatory vacuum. For example, AECB staff actively opposed regulation of radioactive emissions by Environment Canada following more enlightened principles -- especially in and around 1984, when Environment Canada was drafting its Codes of Environmental Practice for Steam-Electric Generating Stations (including CANDU nuclear plants. The relevant Environment Canada Code, in draft, called for emissions of various radionuclides that were from hundreds to hundreds of thousands of times lower than AECB standards. The difference was the result of EC's requirement for Best Practicable (abatement) Technology, compared to AECB's interpretation of "ALARA".

  In addition, AECB's supposedly exclusive jurisdiction and "regulation" of radioactive emissions have been used as an excuse by the Ontario government in exempting radioactive reactor emissions from the first-phase, monitoring regulations of MISA (the Municipal-Industrial Strategy for Abatement, a body of regulations which control emissions by requiring Best Available Technology Economically Achievable), and more recently (still in draft) in exempting radioactive uranium refinery emissions from the second-phase, control regulations of MISA.

We would recommend that AECB either (1) develop meaningful emissions regulations that conform to the prudent approach used to limit the releases of other (*i.e.*, non-radioactive) toxins, eco-toxins, mutagens, teratogens, and carcinogens, or (2) make it clear that federal and provincial environmental regulators are welcome to do so, and gradually withdraw from the field.

The implications of the two alternative approaches for AECB priorities and staff allocation are obviously quite different. In the former alternative, many more staff would have to be allocated to the job to start doing it properly; in the latter alternative, many fewer staff would be needed, as AECB could gradually stop doing the job of setting DRLs -- although Environment Canada and the provincial Ministries of Environment would be called upon to allocate higher priority and more staff to the regulation of radioactive emissions.

APPENDIX II

Excesses of Childhood Leukemia and Birth Defects around CANDU Stations (Section 4 of Energy Probe's February 16, 1994 submission to AECB's Staff Allocation Project)

Having sponsored research that uncovered (1) a very statistically significant excess of Down's Syndrome in Pickering, and a less significant excess in Ajax (the two communities closest to the Pickering A and B NGSs); and (2) a 40% statistical excess of childhood leukemia deaths near the Pickering A and B and Bruce A and B NGSs, which is 97% statistically significant according to a traditional one-tailed significance test; AECB staff have chosen to announce publicly and repeatedly that "the results may be due to chance" and that no further research or action is appropriate.

In fact, when I presented AECB staff with a pre-publication draft of my own analysis, showing that the 40% statistical excess of childhood leukemia deaths near the Pickering A and B and Bruce A and B NGSs was 97% statistically significant (and therefore very unlikely to be "due to chance"), AECB staff responded extremely inappropriately:

- On each of the three mornings after receiving the analysis, AECB held high-level interdepartmental staff meetings, not to ascertain the truth or significance of the analysis, but obviously to discredit it and to "contain" the public impact of its release. (*Cf.* memorandum from S. Ching to J. Waddington dated September 6, 1991, re: "N. Rubin's Draft Comments on the Two AECB Reports on Childhood Leukaemia Around Nuclear Facilities", AECB file 40-0-0)

- A decision was taken at those meetings to hire two outside experts to review the analysis, again not to ascertain its truth or significance, but expressly "to add more credibility to the conclusions of our internal review" -- *i.e.*, that the analysis was baseless, and the AECB-sponsored research was adequate, and that the excess in leukemia mortality need not be considered "significant". Hugh Spence, head of AECB's so-called "Office of Public Information" (about which more later), suggested in the meeting of September 5, 1991 that "a write-up about this matter in the next issue of the [AECB] Reporter might be appropriate." (*ibid.*)

- In fact, one of the two outside experts found serious fault with the AECB-sponsored study as well as my reanalysis of it. (Letter of 21 October 1991 from Dr. S. Raman to AECB's Dr. P. Duport) The other -- Dr. Park Reilly of Reilly Consultants and University of Waterloo -- concluded that my analysis was correct, and my statistical methodology and conclusions -- *i.e.*, that the excess should be considered statistically significant, and that it was very unlikely to be due to chance -- were preferable to those of the AECB-hired experts. (Letter of 16 September 1991 from Dr. Park M. Reilly to AECB's Dr. P. Duport)

- AECB staff, frustrated in their attempt "to add more

credibility to the conclusions of [their] internal review", continue nonetheless to cling to that conclusion -- that the excess is not statistically significant and is likely due to chance. (Letter of January 15, 1992 from AECB's J. G. Waddington to N. Rubin)

- Not surprisingly, Mr. Spence's *AECB Reporter* has still not told its readers (of which I am one) anything about the results of this contract research.

- Even the AECB's Board have not been told the results or the significance of my analysis, or of this contract research. In fact, the only Board Member Document that apparently refers to it at all -- the Annual Report to the Atomic Energy Control Board on the Regulatory Research and Support Program 1991/1992, BMD 92-148, on pp. 188-189 -- totally misrepresented the results of the research. Specifically, the AECB Staff reported the following to its Board as the Final Results for each of the two reports (AECB research projects Nos. 7.173.1 and 7.174.1):

> The contractor has verified and confirmed that the statistical method used by the authors of the [AECB-sponsored] report were adequate, and that the lack of significant correlation between the occurrence of leukemia and the proximity of nuclear facilities was genuine.

- On August 27, 1992, I sent Dr. Reilly copies of three items: Dr. Waddington's January 15, 1992 letter to me; the review of the other outside expert, Dr. Raman; and p. 189 of BMD 92-148, including the fallacious summary of Dr. Reilly's own research results.

- As a result, Dr. Reilly wrote to AECB's Dr. Duport on 14 October 1992 suggesting that the report in BMD 92-148 was "a misrepresentation of my findings". Dr. Reilly also included "a review of the statistical situation in the light of Dr. Raman's report in which I find several mistakes." He indicated that he would not publicize his letter or report, or share it with me, pending Dr. Duport's reply.

- On 9 November 1992, Dr. Duport responded to Professor Reilly (AECB file 37-7-174-1), thanking him for his letter and review, and promising that "the results of the reviews [of Dr. Reilly's documents] will be sent to you as soon as they are available." About the misrepresentation of Dr. Reilly's findings, Dr. Duport wrote:

> In the meantime, I must admit that our statement, in the section "Final Results", page 189 of the AECB Annual Report 1991/1992,

> is a serious oversimplification [*sic*] of the conclusions of your original report. We should have quoted your report most [*sic*] widely and indicated that the level of significance of the type of epidemiological data we were dealing with depends on the statistical methods and assumptions used in the analysis.
>
> Sincerely yours...

- On 24 December 1992, Dr. Duport faxed a further 5-page letter to Professor Reilly. In it, Dr. Duport first reminds Professor Reilly that his November 9 letter already acknowledged the fact that in BMD 92-148 "the AECB has not reflected the spirit, and the letter, of your review of Mr. N Rubin's interpretation ..." Neither in this letter nor in that of November 9, however, does Dr. Duport indicate any intention to correct the record or even to inform AECB's Board that they have been misinformed about the results of this research. In the rest of Dr. Duport's letter, he reaffirms that "we have concluded that Mr. Rubin's interpretation and his use of statistical terminology are incorrect," and explains why Dr. Reilly's findings, and mine, were rejected. Some of that explanation is clearly erroneous. For example, on the choice of a one-tailed versus a two-tailed significance test, he writes:

  > ...one can see clearly that the discussion is somewhat irrelevant to the present situation, *since the overall conclusions in the two AECB reports would not change even after the application of a one-sided test.* [Emphasis added. The statement is wrong, and is, as far as I can see, neither defended nor explained in Dr. Duport's letter.]

  At the end, Dr. Duport reasserts, once more, the AECB staff view that "the excesses which were detected might have been due to chance" and expresses the "hope this will conclude this series of discussions..."

- On 28 December 1992, Dr. Reilly wrote again to Dr. Duport, suggesting that

  > Canadian children and their parents deserve something better than a statement that the observed increase MIGHT be explainable by chance. I believe this implies an obligation on your Board or some other agency to make every effort possible to resolve the uncertainty.

Dr. Reilly also included a copy of a letter he sent to me that day, sharing all this correspondence with me.

Clearly, I agree with Dr. Reilly that Canadian children and their parents deserve something better than the treatment they have received from AECB staff in this matter. I would add that AECB's Board of Directors also deserve something better than the treatment they have received from AECB staff in this matter.

I would recommend that AECB staff promptly report the current state of this controversy to AECB Board, and begin an internal investigation of AECB staff's consistently biased handling of the matter. Failing that, I would expect to bring the matter before the AECB Board myself.

I would further recommend that AECB staff acquire the expertise and the motivation to seek out the truth of this matter, wherever it leads, rather than to misuse its power and its research budget to arrive at results that justify past and present regulatory decisions. As a first step, I would recommend that case-specific information be gathered on the victims of childhood leukemia and Down's Syndrome in the vicinity of Pickering and Bruce, to see if they share any characteristics that could point toward a cause. (An informal survey of Down's Syndrome victims near Pickering, by a CBC reporter, suggested that many of them were born in a small neighborhood during a small time interval. If true, that information would likely be useful in determining a cause.)

March 10, 1994

Dr. Mark Goldberg, Chair
Dr. Ralph Stanley, Tritium Working Group Chair,
Advisory Committee on Environmental Standards
40 St. Clair Ave. West, Suite 401
Toronto, Ontario M4V 1M2 **VIA FAX TO 314-9270** (10 pp. total)

Dear Drs. Goldberg and Stanley:

It was good to meet with you on February 28, to discuss the proposed Interim Ontario Drinking Water Objective (ODWO) for tritium. Following are some supplementary submissions from Energy Probe, in response to that discussion, and in response to our subsequent reading of your Committee's January 1992 report, *A STANDARD FOR N-NITROSODIMETHYLAMINE (NDMA): A recommendation to the Minister of the Environment*.

These supplementary submissions are organized into sections, as follows:

1. Judging tritium as a "priority pollutant" and a "persistent toxin", including the issue of bioaccumulation.

2. What is an "acceptable" level of cancer from tritium in drinking water?

3. Some reasons to go beyond an arbitrary level of "acceptable risk", toward "virtual elimination" or "zero emissions".

4. ACES should not adopt a double standard of acceptable risk.

5. Should the tritium ODWO be compromised on socioeconomic grounds out of concern for the needs of nuclear reactor operators? Does ACES have enough information to defend such a compromise?

6. What I know about the recent and ongoing releases of radioactive liquid wastes from the Fermi-2 nuclear plant into Lake Erie.

Thank you again for the invitation to comment, and I hope you find these comments helpful.

Sincerely,

Norman Rubin
Director, Nuclear Research
and Senior Policy Analyst

Energy Probe Research Foundation
225 BRUNSWICK AVENUE, TORONTO, ONTARIO M5S 2M6 Phone (416) 964-9223 Fax (416) 964-8239

Energy Probe's supplementary submission to
the Advisory Committee on Environmental Standards
regarding the proposed
Interim Ontario Drinking Water Objective for Tritium

Norman Rubin, Director of Nuclear Research
March 10, 1994

Section 1. Judging tritium as a "priority pollutant" and a "persistent toxin", including the issue of bioaccumulation.

In my meeting with the Committee, on February 28, I had indicated that tritium would be considered a "priority pollutant" -- and promoted to Ontario's Effluent Monitoring Priority Pollutants List or EMPPL -- in virtually every category of concern except bioaccumulation, and that even in that category, tritium was of some concern.[1] We then (perhaps confusingly) got into a discussion of the sub-issue of the possible bioaccumulation of tritium.

Perhaps it would be most useful to review the general issue -- *i.e.*, does tritium qualify as a priority pollutant -- to ensure that the specific concern about bioaccumulation (which is admittedly weak in the case of tritiated water) doesn't obscure the larger point.

The Effluent Monitoring Priority Pollutants List, 1988 Update[2] indicates, in Tables 1 and 3, that a pollutant should generally be "promoted" to the Priority Pollutants List if it meets or exceeds any one or more of the following criteria:

- Environmental persistence: A finding that a substance's environmental half-life $t_{1/2}$ exceeds 50 days "does not cause promotion to the EMPPL, but may support promotion based on other parameters. [*op. cit.*, footnote to Table 3]" Tritium emissions into the Great Lakes have an environmental half-life that is a function of both the flushing rate of the Great Lakes (in the order of a one-year half-life, as I understand) and the 12.3-year radioactive half-life of tritium, and that would clearly exceed 50 days. Tritium's promotion to a "priority pollutant" on the basis of most of the following criteria would clearly be supported by this exceedence.

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1. Of course, in that list, as in Ontario's MISA regulations, the Ministry consistently ignores radioisotopes, so tritium is artificially excluded from that list.

2. Ontario Ministry of the Environment, Hazardous Contaminants Coordination Branch, March 1989, reprinted May 1989.
(See my 300-page "Exhibit 597", pp 157-164.)

- Bioaccumulation: promote if BCF[1] >500 or Log k_{ow} >4.0. According to this test, tritiated water emissions *would not* be promoted to EMPPL on the basis of this criterion, although (as I explained in my oral presentation), the toxicity[2] of emitted tritiated water (HTO) -- and *a fortiori* of elemental tritium (T_2) -- does increase after its release, which is a phenomenon analogous to bioaccumulation (and one that is ignored in both the *Rationale Document* and the derivation of AECB emission limits). This increase in toxicity occurs by the partial conversion of HTO into the more toxic organically bound tritium or OBT. Elemental tritium -- T_2 -- would first completely convert, within a matter of hours or a day or two, into HTO, which is thousands of times more toxic than T_2,[3] and then partially convert over time into the even more toxic OBT. If this increase in toxicity were considered equivalent to a bioaccumulation, then pure or elemental tritium *would* be promoted to a "priority pollutant" on the basis of this criterion.

- Acute lethality: promote if oral LD_{50} <50 mg/kg. For an adult human, an LD_{50} dose of tritium, ingested as tritiated heavy water (DTO), is 3.9 mg (or 3.7 mg of HTO) ingested once. Since human adult ingestion of water clearly exceeds one kg (= 1 litre) *per day*, a concentration of 3.9 mg/kg of DTO, or 3.7 mg/kg of HTO, would exceed the oral LD_{50} dose within one day's consumption. Tritium would be promoted to a "priority pollutant" on the basis of this criterion.[4]

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1. BCF = Bioaccumulation (or Bio-Concentration) Factor.

2. By "toxicity" here, I mean to include carcinogenicity, teratogenicity, mutagenicity, etc. Each of the "more toxic" forms generally remains longer in the human body (and in other life forms as well), giving it a longer time to administer its dose of radiation.

3. According to Ontario Hydro (see my "Exhibit #597", p. 7), the inhalation conversion factor for tritium as HTO is 2.0×10^{-11} Sv/Bq plus a further 2.0×10^{-11} Sv/Bq for skin absorption, for a total of 4.0×10^{-11} Sv/Bq. For tritium as HT the corresponding figure is 2.4×10^{-15} Sv/Bq, making it a factor of over 16,000 less effective at delivering radiation, therefore less toxic, carcinogenic, etc. (For this purpose, T_2 and HT are equivalent.)

4. The calculation is based on the following constants and assumptions: a human adult LD_{50} of radiation is 4 Sv (after, *e.g.*, UNEP, which suggests that it may be as low as 2.5 Sv in the absence of medical care -- see my "Exhibit #597", pp. 3-5. Note that the official Quality Factor (Q) for tritium is generally set at 1, so 1 Gray or Gy = 1 Sievert or Sv.); the "committed effective dose equivalent conversion factor" for adult ingestion of HTO (or DTO) is 2.0×10^{-11} Sv/Bq (after Ontario Hydro -- see

- Sublethal Effects, Non-Mammals: I have no direct information on this aspect of tritium's toxicity.[1]

- Sublethal Effects, Plants: I have no direct information on this aspect of tritium's toxicity.

- Sublethal Effects, Mammals: promote if oral NOEL[2] < 10 mg/kg. UNEP (see my "Exhibit #597", p. 5) suggests 1 Gy (or 1 Sv) as the level of radiation at which "early effects" on humans begin. The AECB-sponsored Chalk River study on the RBE of tritium's beta rays in mice (citation in footnote 1 on p. 10 of my written submissions to ACES) found strong evidence of "decrease in time to death" (as I discuss on p. 13 of my February 24th submission -- see also my "Exhibit #597", p. 226) at calculated tritium-radiation doses as low as 0.85 Gy (or 0.85 Sv, at Q=1). Using the same calculations as above under "acute lethality", 1 Gy would be received by an adult human from a single oral ingestion of 0.9 mg of HTO (3.7 mg ÷ 4), This quantity is significantly smaller than the 10 mg specified, so tritium would also be promoted to a "priority pollutant" on the basis of this criterion.

- Teratogenicity: promote if terata or developmental anomalies at < 1000 mg/kg/day. Since tritium crosses the placenta and exposes the fetus to radiation which is a known teratogen, and EMPPL's threshold "promotion dose" of 1000 mg/kg/day is enormous in the case of tritiated water (remember that 3.9 mg is acutely lethal to an adult human), it is clear that tritium

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my "Exhibit #597", p. 7); pure tritium's radioactivity level is approximately 10,000 Ci/g, or 3.7 x 10^{14} Bq/g (references or calculations on request); and the mass ratio of T in DTO, based on the atomic weights of the constituents, is 3 ÷ (2+3+16) = 0.143. For T in HTO, the mass ratio is of course 3 ÷ (1+3+16) = 0.15.

I am somewhat unsure about whether the units for the LD_{50} oral dose in the EMPPL -- mg/kg -- actually refer to kg of drinking water, or total ingested food and drink, or even of body mass. Since all the alternatives involve more kilograms than drinking water alone, any interpretation other than the one I've adopted here would further strengthen the case.

1. Ontario's MISA Monitoring Regulations called for toxicity testing of effluents, at several dilutions, with *daphnia magna* (water fleas) and trout. Unfortunately, Ontario Hydro's radioactive emissions into the Great Lakes were expressly exempted from the MISA Monitoring Regulations for the Electricity Generating Sector, so this information is not available. See my "Exhibit 597", pp. 165-224.

2. NOEL = No Observed Effects Level.

would also be promoted to a "priority pollutant" on the basis of this criterion.

- Genotoxicity/Mutagenicity: promote if described by any of three narrative categories, of which the category of most concern is "genotoxic/mutagenic, usually with direct interactions with DNA." The radiation that tritium delivers is clearly all of the above, and has been demonstrated to cause genetic effects in mice and other laboratory animals. Tritium would also be promoted to a "priority pollutant" on the basis of this criterion.

- Carcinogenicity: promote if described by any of five narrative categories, of which the category of most concern is "direct-acting carcinogen that interacts with generic material." Tritium, presumably by way of the radiation that tritium delivers, is clearly such a direct-acting carcinogen in all animals studied. Tritium would also be promoted to a "priority pollutant" on the basis of this criterion.

Incidentally, tritium would be classified under Criterion A (or possibly B) of the EMPPL Exposure Assessment Criteria listed in Table 2, further supporting its promotion to the EMPPL.

In short, there can be no doubt that tritium, in both of its commonly emitted forms, would be an odds-on favourite to make Ontario's Effluent Monitoring Priority Pollutants List or EMPPL -- if it were only considered for inclusion. By the same token, it would probably (and should) qualify for the more recent and more powerful *Candidate Substances List for Bans or Phase-Outs*.

Section 2. What is an "acceptable" level of cancer from tritium in drinking water?

The "acceptable risk" level ACES has adopted in its 1992 report on NDMA is identical to the one Energy Probe has recommended for tritium on pp. 6-7 of our February 24th submission.[1] As explained

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1. For example, from p. 16 of the NDMA report: "ACES recommends that the following assumptions be used in deriving the risk assessment for future drinking water contaminant standards: length of average rat lifespan of 2 years, *negligible risk level of* 10^{-6} and the use of average water consumption of 2 litres per day. [emphasis added]"
The fact that the 10^{-6} refers here to a lifetime incremental cancer risk from a lifetime of exposure is made clear in two places in the same NDMA report: (1) On p. 12, where we are told that a risk level of 10^{-5} "means ... 1 additional cancer death among 100,000 people"; and (2) pp. 2-3 of the Ministry's Summer 1991 Information flyer, reprinted in Appendix 7: "The health risk of NDMA exposure at various levels *over a lifetime* (incremental

on p. 14 of that submission and in our oral submissions, that risk level is approximately 750 times lower, or more protective, than the level called "acceptable" in the Ministry's *Rationale Document*, which led directly to the proposed ODWO for tritium of 7,000 Bq/L. ACES's definition of a negligible risk level would naturally lead, without any further revisions, amendments, or corrections to the rationale in the Ministry's *Rationale Document*, to an ODWO approximately 750 times lower than the proposed 7,000 Bq/L, or approximately 9 Bq/L of tritium.[1]

Section 3. Some reasons to go beyond an arbitrary level of "acceptable risk", toward "virtual elimination" or "zero emissions".

With tritium, as with NDMA, there are good reasons to go even beyond such an arbitrary level of "acceptable risk", toward "virtual elimination" or "zero emissions". These reasons include prudence in the face of our own ignorance; concern for synergy of multiple toxins and carcinogens; the multiplicity of toxins and carcinogens, which (even without synergy) could lead to unacceptable results from the sum of many "acceptable" insults; and an aversion to compromise the rights of Ontarians -- civil, property, and environmental -- to pure, safe, clean water.

For example, on p. 7 of the NDMA report, we find: "ACES strongly agreed with the principle of virtually eliminating persistent

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...Continued...

lifetime cancer risk) was assessed. ... The 9 ppt IMAC for NDMA represents an incremental lifetime cancer risk of 1 in 100,000."

1. For the Committee's convenience, following is our derivation of a tritium ODWO from the "negligible risk level" of 10^{-6} incremental lifetime cancer risk:

- The International Commission for Radiological Protection (ICRP) has established a risk coefficient of 5×10^{-2} fatal cancer risk per Sv of radiation. (See p. 9 of the *Rationale Document*.)
- As before, I assume here that 40% of all radiation-induced cancers are fatal cancers. (I have seen estimates ranging from about 1/3 to about 1/2.) Accordingly, the corresponding risk coefficient for total cancers is 12.5×10^{-2} lifetime cancer risk per lifetime Sv of radiation. Equivalently, 8×10^{-6} Sv in a lifetime creates an additional 10^{-6} lifetime risk of cancer.
- Assuming, generously, that tritium is the only source of radiation considered, and that drinking water is the only source of tritium, we can apply Ontario Hydro's conversion factor of 2×10^{-11} Sv/Bq for ingested tritium. 8×10^{-6} Sv $\div$ 2×10^{-11} Sv/Bq = 400,000 Bq lifetime ingestion of tritium.
- Assuming, generously, only 60 years of lifetime at risk of cancer initiation (see our earlier submission), at 365 x 2 litres per year, = 43,800 litres of drinking water consumed.
- 400,000 Bq of tritium $\div$ 43,800 litres of drinking water = 9.13 Bq/L.

toxic substances from the environment. NDMA is persistent in ground water and is a probable human carcinogen." (Tritium is persistent in surface waters and is a certain human carcinogen.)

Also on p. 7: "ACES further recommends that, because NDMA is a probable human carcinogen, the standard be reviewed in five years with the goal of reducing the tolerable limit towards zero ..."

On p. 9: "ACES recommends that the virtual elimination of known or suspected carcinogens from drinking water be a guiding principle in setting drinking water standards."

Section 4. ACES should not adopt a double standard of acceptable risk.

Despite the urging of Ontario Hydro, and despite the models of the Atomic Energy Control Board and of the Ministry's own *Rationale Document*, ACES should not adopt a double standard of acceptable risk -- *e.g.*, one for chemical toxins like NDMA, and another for radioactive toxins like tritium. Nor should ACES adopt one standard for totally artificial substances and another for substances that are also produced naturally (albeit at tiny levels) like tritium.

Should ACES have the urge to compromise or temper its principles of acceptable risk and public health in this case, it should do so explicitly, on socioeconomic grounds. Indeed, it would appear justified to make a small compromise in this case, up to a point, by raising the ODWO to the so-called "background" level of tritium -- the level, dominated by fallout from atmospheric weapons testing, found in areas remote from nuclear reactors. At present, that background tritium level is approximately 9 or 10 Bq/L, judging by Appendix E.1. of the *Rationale Document*.[1]

Section 5. Should the tritium ODWO be compromised on socioeconomic grounds out of concern for the needs of nuclear reactor operators? Does ACES have enough information to defend such a compromise?

Given the woeful lack of data on the nature and causes of tritium emissions from nuclear reactors in Ontario (which are alone responsible for tritium levels elevated above "background"), and on the difficulty or expense of abating them, it is extremely unlikely that ACES will be able to defend any further compromise

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1. The fact that these levels are falling as atmospheric nuclear weapons testing recedes into the past gives further justification for a five-year review to move toward virtual elimination.

on socioeconomic grounds.[1] Rather than present an indefensible compromise, ACES should recommend that the tritium ODWO be set at background levels.

Further, ACES must be mindful of the (unfortunate) fact that the exceedence of an ODWO does not automatically trigger emissions reductions or Water Treatment Plant closures, but is only "a signal to pursue certain courses of action, such as investigation of the cause or implications of the elevated level." (See also page 8 of our February 24th submission.) It is far from obvious that the costs of those "courses of action" would be unacceptably high to Ontario Hydro and Atomic Energy of Canada. Indeed, we have presented information in our earlier submission indicating that the costs of significant emissions abatement may be very low.[2]

Section 6. What I know about the recent and ongoing releases of radioactive liquid wastes from the Fermi-2 nuclear plant into Lake Erie.

During my meeting with the Committee, we briefly discussed the recent releases from the Fermi-2 nuclear plant, and I have since been asked by ACES staff if I could provide further information on them. Unfortunately, I don't have much that is solid or first-hand, but following, for your convenience, is what I think I know. I am informed[3] that the spill within the plant, which is now being slowly released to the environment, consists of two large batches of slightly radioactive water:

Batch #1: 532,840 gallons or 1,998,150 litres of water (in the condensate storage tank) contaminated with 1.22 Bq/litre of unspecified radionuclides, primarily Cesium 134 and Cesium 137 (= 2,437,743 Bq total); and

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1. See p. 144 of my "Exhibit #597" for a shocking demonstration of Ontario Hydro's ignorance on this subject in December 1991.

2. For example, it should not be very expensive for Ontario Hydro to filter its unfiltered pump-outs of radioactive liquid wastes (The filters are actually installed, but virtually never used, as discussed at the end of this submission.) That filtered but still-tritiated water should then be an acceptable -- even an advantageous -- feedstock for Ontario Hydro's heavy-water plant at Bruce, or perhaps even for its heavy-water upgraders, at each station. Since the waste water would usually contain much more heavy water than raw Lake Huron water (the heavy-water plant's normal feedstock), there should be a savings in energy, H_2S losses, etc.

3. I was informed by Irene Kock, whom you know, who has received a fax of a U.S. Nuclear Regulatory Commission Docket (#50-341) from a colleague in the U.S.

Batch #2: 500,000 gallons or 1,875,000 litres of water (in the rad-waste building basement) contaminated with 14.8 Bq/litre of unspecified radionuclides (perhaps also primarily Cesium 134 and Cesium 137) (= 27,750,000 Bq total).

Total volume 3,873,150, total radioactivity 30,187,743 Bq.

Assuming that all the radioactivity is in the form of cesium, and using some of the same calculations I performed in my February 24th submissions on (for example) Ontario Hydro's August 1992 tritium spill, I arrive at the following equivalences:

Ontario Hydro's chart (p. 8 of my "Exhibit #597) gives 2×10^{-8} Sv/Bq conversion factor for adult ingestion of Cs-134, and 1.4×10^{-8} Sv/Bq conversion factor for adult ingestion of Cs-137. Taking the average, 1.7×10^{-8} Sv/Bq, as a conversion factor, and applying it to the grand total of 30,187,743 Bq in the two batches, we get a committed effective dose equivalent of 0.513 Sv (or person-Sv) from human ingestion of the entire quantity. At 4 Sv = 1 adult human LD_{50} dose, for example, it is about one-eighth of a single human adult LD_{50} dose. (Recall, for comparison, that Ontario Hydro's 5-year average emissions of tritium in 1986-1990 were about 30,000 human adult LD_{50} doses per year, and that Ontario Hydro's August 1992 tritium leak into Lake Ontario contained roughly 10,000 human adult LD_{50} doses.)

Note also that the Liquid Derived Emission Limit for "gross beta, gamma activity" emissions (of which waterborne Cesium emissions would be part)[1] for the Darlington station stands at 1.1×10^{13} Bq per month.[2] At that rate, Ontario Hydro could emit both of Fermi-2's batches of radioactive water about *every 7 seconds* and still (just) meet its Derived Emission Limit. Of course, it is required by AECB that Ontario Hydro try to keep to 1% of those limits, which would mean that a release that size could take place *every twelve minutes* at Darlington with the AECB's blessing.

It is also illustrative to compare the radioactivity in the two batches of Fermi-2 liquid waste with Ontario Hydro's *actual emissions* of "gross beta, gamma activity" in some recent years. The bottom table on page 128 of my "Exhibit 597" present Ontario Hydro's reported "gross beta, gamma activity" emissions to water, in Curies, for each of their stations, for each of the years

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1. Both Cs-134 and Cs-137 decay by emission of a beta particle and gamma rays.

2. From Ontario Hydro's 1986 DEL document as submitted to AECB, p. 23. This information also appears in Ontario Hydro's twice-revised response to our interrogatory on the subject (see pp. 130-131 of my "Exhibit #597"), which reports the equivalent values of 3.0×10^{2} *Ci*/month and 1.3×10^{14} Bq/*year*.

1986-1990. For ease of comparison, the grand total of 30,187,743 Bq in the two Fermi-2 batches equates to 8.16×10^{-4} Ci, or a bit less than one one-thousandth of a Curie. The smallest annual emission from all of Ontario Hydro's stations in the entire five-year period is 1.2×10^{-2} Ci from Darlington in 1989 (when only one reactor was operating for only part of the year). Even that emission is almost fifteen times larger than the total of the two batches of Fermi-2 liquid waste. The largest annual emission listed -- 3.2 Ci from Bruce A in 1986 -- is almost four thousand times larger than the grand total of the two batches of Fermi-2 liquid waste.

In terms of the *volume* of radioactive water, Ontario Hydro tells us (see p. 150 of my "Exhibit 597") that each Ontario Hydro nuclear station pumps out "one tank (approximately 75 m^3 [=75,000 litres]) of low-activity radioactive liquid waste per 12 hour shift. At that rate, the total volume of the two batches would be pumped out of any single Ontario Hydro station every 26 days.

Barring an enormous error in the data I've received about the Fermi-2 pumpouts, it seems clear that Detroit Edison can't hold a candle to Ontario Hydro when it comes to pumping radioactive wastes into the Great Lakes.

This situation is certainly outrageous, but it is not at all surprising to us at Energy Probe, since filtration of all liquid effluents prior to release to the environment "is general practice worldwide", but is virtually never done by Ontario Hydro. [1] For example, in the years 1971-1986 at Pickering, (1) the filters for radioactive liquid waste had been used only once, and on that occasion they plugged up; (2) the Pickering-A Liquid Effluent Monitors had never been put into service; and (3) only one of the 15 agitators on the "Active Liquid Waste Management System" tanks had ever been used, and it had been used only once. (The agitators are required in the plant design, to ensure that analyzed samples are representative of actual emissions.)[2]

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1. Quoted from Hydro's *State-of-the-Environment Report - 1989*, p. 31. Reproduced on p. 9 (or p. 104) of my "Exhibit 597".

2. From AECB's *Health Physics Appraisal Report of the Management of Radioactive Liquid Wastes and Liquid Effluent Monitoring at Pickering Nuclear Generating Station*, May 1986. Reproduced on pp. 93-103 of my "Exhibit 597". (Beware the pages "94A", "96A", etc., and that these pages are slightly out of order.) See especially p. "97A" for the facts cited.

Ontario

Advisory Committee on Environmental Standards

Comité consultatif des normes environnementales

40 St. Clair Avenue West
Suite 401
Toronto ON M4V 1M2

40, avenue St. Clair ouest
Bureau 401
Toronto ON M4V 1M2

March 25, 1994

Mr. Norman Rubin
Director
Nuclear Research
Energy Probe Research Foundation
225 Brunswick Ave.
Toronto, Ontario
M5S 2M6

Dear Mr. Rubin:

Thank you for your submissions regarding the proposed Interim Ontario Drinking Water Objective for tritium. I am writing to request clarification regarding the acceptable level of cancer risk that you refer to on page 7 of the submission dated February 24, 1994, and again on page 4 of the submission dated March 10, 1994.

Attached is a paper from the U.S. Environmental Protection Agency's Science Advisory Board regarding the paradigms that have been developed for risk assessment and risk reduction strategies for radiation and for chemicals. Part of the paradigm the International radiation protection community uses is that natural background exposure to radiation is inescapable and limitations in radiation exposure that are small in comparison to natural background radiation are unwarranted. The clarification that ACES asks of you is whether you feel the cancer risk posed by chemical contaminants and radionuclides is intrinsically different? Should the risk associated with these two types of agents be treated differently, and if not, why not?

Due to the time frame of this consultation, I would appreciate a brief response as soon as possible. Thank you again for your participation in this consultation. I look forward to your reply.

Sincerely,

Mark T. Goldberg Ph.D. DABT
Chair
Advisory Committee on Environmental Standards

April 4, 1994

Dr. Mark Goldberg, Chair
Advisory Committee on Environmental Standards
40 St. Clair Ave. West, Suite 401
Toronto, Ontario M4V 1M2 **VIA FAX TO 314-9270**

Dear Dr. Goldberg:

Thank you for your letter of March 25th and for your telephone message of the same date, and for mailing me the very interesting undated paper from the U.S. EPA's Science Advisory Board entitled *Harmonizing Chemical and Radiation Risk-Reduction Strategies -- A Science Advisory Board Commentary*. I am pleased to see that the EPA paper confirms the claim in my submissions that radioactive emissions and exposures are traditionally much more permissively regulated than chemically carcinogenic emissions and exposures.

Please forgive my delay in responding, but I have just returned to my office after a week out of the country.

In your letter, you requested my comment on (1) whether or not I feel "the cancer risk posed by chemical contaminants and radionuclides is intrinsically different." As you also ask in your letter, (2) "Should the risk associated with these two types of agents be treated differently, and if not, why not?"

My answer, as you might expect from my submissions, is as follows: (1) The cancer risks posed by chemical pollutants like NDMA and radioactive pollutants like tritium -- both of them man-made carcinogens leaked, leached, or spilled into drinking water -- are qualitatively indistinguishable in the context of an ODWO and ACES's mandate. (2) I doubt that there is a single person alive in Ontario today who would have a strong preference between these two types of carcinogenic agents as the cause of his or her cancer. The two cancer risks are obviously identical in nature, and should therefore be treated identically. In fact, I have trouble addressing your "if not, why not" question, because I cannot conceive of a reasonable answer to the opposite proposition: "If the two (identical) risks of identical cancers should be considered different, then *why*?"

It is true -- as my submission and the EPA paper both point out -- that the unusual history of radionuclide control (primarily the fact that it has been dominated by radioactive polluters, and not by independent regulators) has led to a very permissive regime, rationalized by reference to convenience,

Energy Probe Research Foundation
225 BRUNSWICK AVENUE, TORONTO, ONTARIO M5S 2M6 Phone (416) 964-9223 Fax (416) 964-8239

cost, and the undeniable risks of simply living on Earth. (After all, even if we are fortunate enough to escape all other hazards, "natural causes" will surely kill us all.)

That permissive (and intellectually corrupt) regime contrasts starkly with regimes like ACES's, that flow from an honest estimate of the additional cancer risk that Ontarians would consider negligible or *de minimis*, and that reflect Ontarians' desires to reduce and "virtually eliminate" their exposure to avoidable carcinogens and even suspected carcinogens. It would be tragic if ACES were to compromise its prudent principles, as outlined in the NDMA report, in order to "blend in" with agencies like the International Atomic Energy Agency, the ICRP, and the AECB -- the very agencies that have created the present permissive regime for radionuclides, as outlined in my submissions. (See especially Section 3 of my February 24, 1994 submission, and the attachment thereto entitled "The regulatory vacuum concerning 'routine' radioactive emissions".)

The undeniable presence of natural carcinogens, radioactive and non-radioactive, is interesting and unfortunate (as is the presence of crime in Toronto), but none of this is within the control or mandate of ACES. If ACES or the Ontario government can easily decrease Ontarians' exposure to carcinogenic cosmic rays, or to carcinogenic aflatoxin in peanut butter, then by all means, please do it. But if not, then why is it relevant here? These other risks are surely not a logical excuse for increasing the permissible level of artificial tritium in drinking water, which *is* within the control and mandate of ACES and the Ontario government. (For a commendably clear-headed discussion on an analogous issue, see pages 8-9 of ACES's 1992 NDMA report, "Contribution from other sources".)

Furthermore, ACES's present mandate is neither to become a "radiological protection" agency, nor to join the "health physics community", but to recommend an ODWO for one particular persistent carcinogen which happens to be radioactive: tritium. And in the case of tritium -- unlike cosmic rays and radon -- natural production is not an issue, because natural production is trivially small compared to Ontario Hydro's (and AECL's) rate of production and release. (See, for example, my February 24 submission, bottom half of page 12.)

If, despite these submissions, you are still tempted to recommend a higher acceptable risk level from tritium because there are larger natural sources of radiation, like cosmic rays and radon, then I would submit the following: I believe that the presence of other carcinogens, including natural radiation -- by exposing more people to first- and second-hand knowledge of the terrible pain, suffering, and indignity of cancer -- has clearly decreased, not increased, the cancer risk that Ontarians would "accept" or consider negligible or *de minimis* from tritium in drinking water. (Put simply, whenever people watch one of their loved ones die of cancer, they pray all the more fervently that they themselves will die of something else.) Thus, the nuclear

establishment's rationalization that its excess cancer risks are "a small percentage of background" cancer risks is democratically absurd, as well as morally bankrupt.

I hope these comments are helpful, and I wish you well in your deliberations.

Sincerely,

Norman Rubin
Director, Nuclear Research
and Senior Policy Analyst

Executive Summary

On December 16, 1993, The Honourable C.J. (Bud) Wildman, Minister of the Environment and Energy, wrote to the Advisory Committee on Environmental Standards (ACES) and requested that ACES conduct a public consultation on the Ministry's proposed Interim Ontario Drinking Water Objective (ODWO) for tritium of 7,000 Becquerels per litre (Bq/L). This referral arose as a result of public concern about a plan to expand the existing water supply plant in Ajax, Ontario. This plant would draw raw water from Lake Ontario and is adjacent to the Pickering Nuclear Power Generating Station (PNGS), which discharges tritium in waste water into the lake.

Tritium is a radioactive form of hydrogen. It is long lasting, with a radioactive half-life of 12.3 years and a biological half-life of 10 days to 2 years. Tritium occurs naturally, but the majority of tritium in Lake Ontario is a byproduct of CANDU nuclear reactor operations. Conventional water treatment is not able to remove tritium from drinking water as it passes through the water treatment plant. The only practical way to reduce tritium levels entering surface waters drawn by water treatment plants is to reduce emissions from CANDU nuclear facilities.

ACES invited public comment on the proposed ODWO by using a large mailing list and by advertising in newspapers. Respondents were sent a copy of the Ministry's *Rationale Document for the Development of an Interim Ontario Drinking Water Objective for Tritium* (MOEE 1993) and were asked to comment on it. Public interest in this issue was widespread and resulted in new information not contained in the Rationale Document being brought to the attention of ACES. For example, ACES learned that readers of the Rationale Document would probably underestimate the fatal cancer risk posed by the proposed ODWO. The Ontario Ministry of the Environment and Energy's (MOEE) policy on Drinking Water Objectives states that lifelong exposure (estimated to be 70 years) must be considered. The documents used in deriving the ODWO for tritium, however, consider exposure for only one year. Although this approach has often been taken by nuclear regulatory agencies, it is clearly at odds with MOEE's policy on drinking water guidelines. Exposure to 7,000 Bq/L represents a risk of approximately 340 excess fatal cancers per million people exposed over their entire lives.

In many regulatory agencies, including MOEE, 1 excess cancer per million people exposed is often considered acceptable if there are multiple media for exposure to a given contaminant and a large population is affected. A higher level of acceptable risk of 1 excess cancer per hundred thousand people exposed is often used to derive standards when small populations are affected, and their exposure results from only a single medium. Exposure to tritium in Ontario occurs through drinking water and the affected population may be large. Exposure may also occur via air and perhaps, food. Therefore, ACES recommends that an acceptable level of risk for excess cancers due to exposure to tritium be 5 per million people at risk, as suggested by the MOEE in the Rationale document. Given a 70 year (lifelong) exposure, and assuming the annual

risk is additive, this would result in an Ontario Drinking Water Objective of 100 Bq/L.

There are many other sources of uncertainty and concern which were brought to the attention of ACES by members of the public during this consultation. For example, the risk calculations do not directly address non-fatal cancers nor health effects other than cancer, and there is scientific uncertainty regarding the relative biological effectiveness of tritium. Some members of the public also expressed concern that the most sensitive subpopulation (the developing fetus) was not considered in the risk calculation. For these reasons, ACES recommends that the ODWO for tritium be reduced over time to 20 Bq/L, corresponding to an acceptable level of risk of 1 excess cancer per million people following lifelong exposure. Several members of the public pointed out that tritium would meet the International Joint Commission's (IJC) definition of a persistent toxic substance and, on that basis, should be virtually eliminated from industrial discharges. Some respondents pointed out that on the basis of the IJC's recent Seventh Biennial report, tritium should be considered a candidate for "zero discharge". Others suggested that tritium be added to Ontario's Priority Pollutants List as it is a known carcinogen which is discharged into Provincial surface waters. ACES endorses these principles and recommends that discussions should be initiated with Ontario Hydro and AECL regarding the feasibility of reducing tritium emission levels from nuclear facilities in Ontario.

ACES consulted the public on the proposed Interim ODWO of 7,000 Bq/L and the feasibility of achieving this level. ACES is not aware of comprehensive information on the feasibility of achieving the lower recommended level of 100 Bq/L, nor was this issue addressed in the MOEE's Rationale Document. However, the monitoring data available through the Ministry's Drinking Water Surveillance Program (DWSP) suggest that 100 Bq/L is rarely exceeded. Therefore, it is a currently achievable standard which will only become more readily achievable as background levels of tritium decline due to the decay of nuclear fallout from atmospheric weapons testing.

The same monitoring data indicate that 20 Bq/L is not currently a routinely achievable standard in drinking water near nuclear facilities. Because conventional water treatment does not remove tritium, ACES recommends that feasibility studies be undertaken with the goal of reducing tritium emissions sufficiently to permit the ODWO to be lowered to 20 Bq/L within 5 years.

In conclusion, ACES recommends that the Ontario Drinking Water Objective for Tritium be set immediately at 100 Bq/L. ACES further recommends that, due to the fact that tritium is a human carcinogen and because of the many uncertainties in the risk assessment, the tolerable level of tritium in drinking water be reduced to 20 Bq/L in 5 years with the goal of further reduction as human contributions to tritium background levels decline. The five year schedule for the reduction acknowledges the need for technical and financial feasibility studies on the ODWO of 20 Bq/L. In addition, ACES recommends that this standard be applied as a health-based Maximum Acceptable Concentration, so that when the drinking water standard is exceeded, an alternative water supply should be made available.

Summary of Recommendations

ACES recommends that the Ontario Drinking Water Objective for Tritium be set immediately at 100 Bq/L. ACES further recommends that, due to the fact that tritium is a human carcinogen and because of the many uncertainties in the risk assessment, the tolerable level of tritium in drinking water be reduced to 20 Bq/L in 5 years with the goal of further reduction as human contributions to tritium background levels decline. The five year schedule for the reduction acknowledges the need for technical and financial feasibility studies on the ODWO of 20 Bq/L. In addition, ACES recommends that this standard be applied as a health-based Maximum Acceptable Concentration, so that when this drinking water standard is exceeded an alternative water supply should be made available.

ACES recommends that a multimedia approach be used in establishing tritium standards. Recognizing the existence of other potential pathways of exposure to tritium in addition to drinking water, ACES further recommends that the Minister of the Environment and Energy should undertake discussions with other jurisdictions to implement this recommendation.

ACES further recommends that the MOEE establish a policy on risk estimation with standard methodologies to evaluate risk and clear criteria for when deviations from that methodology are required.

ACES recommends that radioisotopes that are toxic, persistent, and that have the potential to bioaccumulate should be included in the Priority Pollutant List developed by the MOEE.

ACES recommends that the MOEE undertake a comparative cost analysis of different methods to achieve the recommended ODWO of 100 Bq/L and the five year target of 20 Bq/L.

ACES further recommends that the MOEE ensure that the feasibility of additional tritium emission control strategies be assessed.

ACES recommends that frequent monitoring and timely, regular and public reporting of tritium levels in nuclear facilities' emissions and water treatment plant intakes in the vicinity of nuclear facilities should be ensured by the MOEE.

ACES is unaware of any monitoring program currently in place that would detect tritium pulses. Due to the concerns raised regarding potential risks to the fetus *in utero*, ACES recommends that the MOEE ensure that the timely reporting of periodic tritium pulses is pursued.

A STANDARD FOR TRITIUM

A recommendation
to the Minister
of the
Environment and Energy

ACES strongly supports the principles of pollution prevention and the phase out of persistent, toxic contaminants, like tritium. In keeping with these goals, ACES recommends that discussions should be initiated with Ontario Hydro and AECL regarding the feasibility of reducing tritium emission levels from nuclear facilities in Ontario.

ACES recommends that the Ministry of Labour Radiological Drinking Water Monitoring data should be made available to the public in an accessible and timely manner and published along with the Drinking Water Surveillance Program data.

ACES recommends that follow up studies on long term, low level exposures to radiation be completed as recommended by previous AECB reports, but that these studies not proceed immediately if the cost associated with them would delay the implementation of the recommended standard.

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ACES further recommends that representatives selected by the community be included in the planning committee for future health studies to increase public confidence in the study.

The Globe and Mail, May 31, 1994 p. A4

Tritium limit proposed for water

TORONTO — A proposal limiting the amount of tritium in drinking water could force many Ontario cities, including Toronto, to provide bottled water to the public following spills of the radioactive material from power plants.

An advisory committee for the Ontario Ministry of the Environment and Energy is recommending a drinking-water standard for tritium of 100 becquerels per litre of water.

The proposed level is frequently exceeded in areas drawing water near discharge pipes from Ontario Hydro's 20 nuclear reactors and from an Atomic Energy of Canada Ltd. research station on the Ottawa River.

The current Canadian standard for tritium, a radioactive form of hydrogen considered a carcinogen, is 40,000 bq/l, and the World Health Organization has an objective of 7,800 bq/l.

A becquerel is a unit used to measure radiation.

Both companies could face higher pollution costs to contain their emissions if the new standard is accepted.

The recommendation is being made by Ontario's advisory committee on environmental standards, a group that reports to Environment Minister Bud Wildman. It said that when the proposed standard is exceeded "alternative water supply should be made available" to the public.

— *Martin Mittelstaedt*